



Human Factors of Integrated Systems Health Management

A central requirement of NASA's exploration vision is the development of an operations concept for crewed vehicles. In the current space transportation system, significant mission management functions (such as subsystem failure detection, isolation, and recovery, and flight planning and replanning in response to in-flight anomalies) are performed by a "standing army" of ground personnel working with crewmembers. Considerations of operational cost, crew safety, vehicle reliability, and the loss of real-time communications between ground and vehicles traveling beyond low-earth orbit, mandate a more autonomous operational concept for crewed exploration vehicles.

Background

For crewed spacecraft to operate more autonomously, the crew must be capable of working systems malfunctions with less assistance from the ground. However, enhancing onboard fault detection, isolation, and recovery capabilities is a multifaceted challenge. Compared to the vast processing resources (human and display-based) available on the ground, the resources available onboard a spacecraft are quite limited. To overcome these limitations, many of the information processing tasks currently performed by ground personnel will have to be performed by intelligent software systems residing on the vehicle. Fault management must therefore evolve from an activity performed by teams of human agents (crew and ground) to an activity performed by teams of human agents (crew) and onboard intelligent software systems (machine-based agents).

Three outstanding human factors issues must be resolved as part of defining and validating a valid operational concept for human-machine teaming. First, an appropriate human-machine functional allocation (level-of-automation or LOA) must be determined for a wide variety of subsystem malfunctions. Second, human-machine interfaces must be designed to support the targeted LOA's. Third, the Caution and Warning system must evolve beyond the relatively unsophisticated alerting system it is today into a two-way



touch-sensitive flat panel LCD's. The lab is uniquely equipped to collect a variety of performance measures such as the crew's response time and accuracy when resolving malfunctions.

Research Overview

The Intelligent Spacecraft Interface Systems (ISIS) laboratory is a single-crewmember part-task simulation facility located at NASA Ames Research Center. The ISIS lab consists of a network of PC's and SGI machines that dynamically drive spacecraft cockpit display formats

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including an eye-tracking system that provides real-time measurement of participants' information acquisition strategies and fault management activities. Oculomotor data are combined with an assortment of overt measures, such as control panel switch throws and keyboard presses, to yield a comprehensive "picture" of participants' nominal information processing activities (i.e., their nominal scan patterns), and their fault management activities following the insertion of a systems malfunction.

Work in the ISIS lab is currently focused on evaluating human interactions with an advanced suite of shuttle cockpit display formats developed through Johnson Space Center's shuttle cockpit avionics upgrade project. Patterns of information acquisition are being analyzed to determine whether key design features of the new display formats represent an appropriate "departure point" for the design of user interfaces with more advanced fault detection, identification, and reconfiguration software systems.

Relevance to Exploration Systems

A central requirement of NASA's exploration vision is the development of an operations concept for the crewed vehicles. Considerations of operational cost, crew safety, vehicle reliability, and the loss of real-time communications between ground and vehicles traveling beyond low-earth orbit, mandate a more autonomous operational concept for crewed exploration vehicles.

H&RT Program Elements:

This research capability supports the following H&RT program elements:

ASTP: Advanced Space Operations

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